(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
31 January 2002 (31.01.2002)

PCT

(10) **International Publication Number**
WO 02/09375 A1

(51) **International Patent Classification⁷:** **H04L 25/02**

(21) **International Application Number:** PCT/IB01/01303

(22) **International Filing Date:** 20 July 2001 (20.07.2001)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
TS2000A000004 21 July 2000 (21.07.2000) IT

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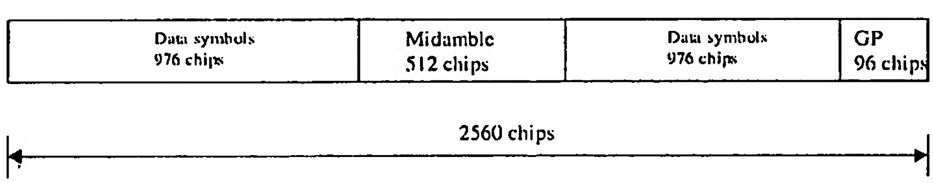
(81) **Designated States** *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) **Designated States** *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** ESTIMATION OF THE DOWNLINK CHANNEL FOR UMTS



(57) **Abstract:** This invention consists of an iterative method for channel estimation in the downlink of the UMTS-TDD component. In addition to the channel impulse response, the algorithm also provides estimates of the users' powers, which are needed to perform multi-user detection. The limited computational complexity allows implementation of the proposed scheme in the Mobile Station (MS) receiver.

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ESTIMATION OF THE DOWNLINK CHANNEL FOR UMTS

The present invention relates to a method for estimating channels in a receiver for the downlink of the TDD (Time Division Duplex) component of the UMTS (Universal Mobile Telecommunication System) and a receiver thereof.

In mobile telecommunications systems, due to bandwidth limitations and multipath propagation, the transmission channel distorts the signal being transmitted, leading to inter symbol interference (ISI). The receiver needs to identify this channel distortion and equalize it. Classical system identification techniques require the use of both system input and output, which leads to the transmission of a training sequence, i.e. a set of fixed data (that do not carry information) that are known to both transmitter and receiver. The use of a training sequence reduces the transmission rate, especially when the training sequence has to be retransmitted often, due to the possibly fast channel variations that occur in mobile communications. To the contrary, blind equalizers adapt without using a training sequence.

In TDD mode of UMTS standard the channel estimation is based on the transmission of training sequences known at the receiver in every data packet. The problem of channel estimation by means of training sequences in receiver of mobile terminals has received much attention in the literature over the past years. Some algorithms operate in the time-domain and are based on a least-square approach . Other schemes operate in the frequency domain and are based on Discrete Fourier Transform (DFT) techniques. A reduced complexity search for the optimum training sequences has been proposed. In conventional systems, channel estimation is performed without taking into account a priori knowledge (Side Information) of the transmit shaping filter. A few time-domain schemes exploiting side information have been recently investigated and it has been shown that side information can improve the estimation accuracy with respect to conventional methods.

In hybrid TDMA (Time Division Multiple Access)/ CDMA (Code Division Multiple Access) systems like the TDD component of the UMTS standard, the problem of channel estimation has been addressed for the uplink, where the base station BS has to estimate up to 16 impulse responses (one for each active user). In the downlink the signals transmitted to the users pass through the same channel. The problem is complicated by the fact that the mobile station does not know which user codes are active in the slot. Figure 1 shows the slot structure of the UMTS-TDD component. We see that there are two fields of data separated by a midamble, which contains the training sequences of the active users and serves to estimate the channel

impulse response and the users' powers. The training signal in the downlink is similar to that used in the uplink. In particular, each active user is associated with a cyclically shifted version of a basic code with good autocorrelation properties. The resulting sequence is fed to a root-raised-cosine pulse shaping filter with roll-off $\alpha = 0.22$. This model allows estimation of the channel impulse responses in the uplink by means of standard techniques. In the downlink the problem of channel estimation is quite different with respect to the uplink, since all users arrive at the mobile station MS through the same channel. Consequently, the channel impulse responses of the users only differ for a scalar factor that depends on the user's power. In particular, if a user is not active in the link then its scalar factor is zero. Thus, in contrast to the uplink situation where N_{ut} different channels must be estimated (one for each active user), a single channel impulse response must be estimated in the downlink.

A discussion of the problem of channel estimation by means of training sequences in receiver is now given.

The received signal is given by

$$r(t) = s(t) + w(t) \tag{1}$$

where $w(t)$ represents the noise contribution, while $s(t)$ is the useful signal component

$$s(t) = \sum_{i=1}^{N_{ut}} \gamma_i \sum_{k=1-W}^{P-1} a_k^{(i)} h(t-kT) \ . \tag{2}$$

In (2), P represents the length of the midamble expressed in chip intervals T, $h(t)$ is the channel impulse response with support in $(0, WT)$, $\boldsymbol{a}^{(i)} = \{a_k^{(i)}; 1-W \le k \le P-1\}$ is the training sequence associated with the ith user while $\gamma_i = \sqrt{P_i}$, P_i being the power of the ith user ($\gamma_i = 0$ if the user is not active). In the UMTS standard the parameters P, W e N_{ut} satisfy the following relation

$$P = WN_{ut} \tag{3}$$

The training sequences $\boldsymbol{a}^{(i)}, 1 \le i \le N_{ut}$ are derived by cyclically shifting a basic code $\boldsymbol{a} = [a_0, a_1, \ldots, a_{P-1}]$ of length P in the following way

$$a_k^{(i)} = a_{|k-(i-1)W|_P} \qquad -W+1 \le k \le P-1, \qquad i = 1,2,\ldots,N_{ut} \tag{4}$$

where the notation $|n|_P$ stands for n modulo P. Without loss of generality, in the following we assume that the desired user is the first one and we let $\gamma_1 = 1$. The received signal is first filtered and then sampled with period $T/2$. The corresponding received samples are expressed by

$$x(n) = x(t)|_{t=nT/2} = \sum_{i=1}^{N_{ut}} \gamma_i \sum_{k=0}^{2W-1} h(k) b_{n-k}^{(i)} + w(n) \qquad 0 \le n \le 2P-1 \tag{5}$$

where $\{h(k);\ 0 \le k \le 2W-1\}$ are the samples of $h(t)$ taken at $kT/2$ and $b_n^{(i)}$ is related to the ith

training sequence by the relation

$$b_n^{(i)} = \begin{cases} a_{n/2}^{(i)} & n \text{ even} \\ 0 & \text{otherwise} \end{cases} \tag{6}$$

From (5) it is seen that $2W + N_{ut} - 1$ parameters must be estimated: the $N_{ut} - 1$ amplitudes $\{\gamma_i; 2 \le i \le N_{ut} - 1\}$ and the $2W$ samples $\{h(k); 0 \le k \le 2W - 1\}$ of the channel impulse response. It is worth noting that accurate estimates of the signal amplitudes $\{\gamma_i; 2 \le i \le N_{ut} - 1\}$ allow to identify the active user codes. This information is essential to perform multiuser data detection. Estimation of the signal amplitudes also allows to achieve a channel Mean Square Error (MSE)

$$MSE = \mathrm{E}\{|h(k) - \hat{h}(k)|^2\} \tag{7}$$

very close to the following theoretical limit

$$MSE_{bound} = \sigma^2 \frac{BT}{P \sum_{i=1}^{N_{ut}} \gamma_i^2} \tag{8}$$

where $B = (1 + \alpha)/2T$ is the bandwidth of the useful signal component and σ^2 is the power of the noise sample $w(n)$. Eq. (8) is derived under the assumption that the amplitudes γ_i are a priori known and the training sequences have ideal autocorrelation properties (i.e., their power spectral density is constant).

The UMTS-TDD standard employs orthogonal spreading codes to provide intrinsic protection against multiaccess interference. Correspondingly, the conventional code-matched filter receiver is optimum for transmission over the additive white Gaussian noise (AWGN) channel. In the presence of multipath, however, signals undergo frequency-selective fading and the spreading codes lose their orthogonality. In such conditions the matched filter detector suffers severe performance degradation due to multiaccess interference. To mitigate this problem, multiuser detection/equalization techniques can be resorted to. As the complexity of the optimum multiuser detector is unrealistically high, suboptimum schemes based on block equalization have been proposed which provide a reasonable trade-off between performance and complexity. The equalizer coefficients can be computed by separately minimizing the mean squared error between the samples at the equalizer output and the data of each active user. This technique represents a suboptimum joint detection strategy and can be used with both linear or decision feedback equalizers (DFE). The DFE implementation, however, is rather complex and has not been used for the downlink. Several schemes based on linear equalization have been recently

proposed and some of them are still investigated. It is worth noting that all these reduced-complexity multiuser detectors require knowledge of the channel impulse response and identification of the active users in the slot.

Thus, it is necessary to jointly estimate the channel impulse response and the users' powers.

It is the object of the present invention to solve the above drawbacks and provide a method for estimating channels in a receiver having a more efficient and improved performance compared to the solutions already known.

In this frame, it is the main object of the present invention to provide a method for estimating channels in a receiver, which is apt to jointly estimate the channel impulse response and the users powers achieving good performance in terms of bit-error-rate.

A further object of the present invention is to provide a channel estimation accuracy superior to that achieved with other existing methods.

A further object of the present invention is to accurately identify whether a given user is active or not.

.In order to achieve such aims, it is the object of the present invention to provide a method for estimating channels in a receiver and/or a receiver incorporating the features of the annexed claims, which form an integral part of the description herein.

Further objects, features and advantages of the present invention will become apparent from the following detailed description and annexed drawings, which are supplied by way of non limiting example, wherein:

- Fig. 1 shows the slot structure of the UMTS-TDD component to be used in association with the method according to the invention.

The method for estimating channels in a receiver is now explained:

The key idea of the method for estimating channels according to invention is of jointly estimating channel response and signal amplitudes starting from signal amplitudes. This approach has the following advantages: *i*) The channel estimation accuracy is superior to that achieved with other existing methods because we exploit the aggregate of all the active users' signals rather than a single signal. *ii*) It is possible to accurately identify whether a given user is active or not.

Consider the $2P$ received samples given in (5). We aim at jointly estimating the channel vector and the signal amplitudes, i.e.,

$$\boldsymbol{h} = [h(0), h(1), \ldots, h(2W-1)]^T \qquad (9)$$

$$\gamma = [\gamma_2, \gamma_3, \ldots, \gamma_{N_{ut}}]^T \tag{10}$$

(the superscript $(\cdot)^T$ indicates vector or matrix transposition) starting from the observed vector

$$\boldsymbol{x} = [x(0), x(1), \ldots, x(2P-1)]^T \tag{11}$$

To this end, we rewrite (5) in matrix notation

$$\boldsymbol{x} = \boldsymbol{P}\boldsymbol{h}_s + \boldsymbol{w} \tag{12}$$

where $\boldsymbol{h}_s$ is a $2N_{ut}W$-dimensional vector containing scaled versions of the channel response $\boldsymbol{h}$

$$\boldsymbol{h}_s^T = [\boldsymbol{h}^T \ \gamma_2\boldsymbol{h}^T \ \gamma_3\boldsymbol{h}^T \cdots \gamma_{N_{ut}}\boldsymbol{h}^T]^T \tag{13}$$

while $\boldsymbol{P}$ is a matrix of dimension $2P \times 2N_{ut}W$ containing N_{ut} blocks, each of dimension $2P \times 2W$

$$\boldsymbol{P} = [\boldsymbol{B}_1 \ \boldsymbol{B}_2 \cdots \boldsymbol{B}_{N_{ut}}] \tag{14}$$

The (n,k)-entry of $\boldsymbol{B}_i$, $1 \le i \le N_{ut}$, is given by

$$[\boldsymbol{B}_i]_{n,k} = b_{n-k}^{(i)} \qquad 0 \le n \le 2P-1, \qquad 0 \le k \le 2W-1 \tag{15}$$

with $b_n^{(i)}$ as defined in (6). The noise-vector $\boldsymbol{w} = [w(0), w(1), \ldots, w(2P-1)]^T$ is zero-mean and Gaussian, with covariance matrix

$$\boldsymbol{C}_w = \mathrm{E}\{\boldsymbol{w}\boldsymbol{w}^H\} = \sigma^2 \boldsymbol{I}_{2P} \tag{16}$$

where $\boldsymbol{I}_{2P}$ is the identity matrix of order $2P$ and the superscript $(\cdot)^H$ represents Hermitian transposition.

We begin by estimating $\boldsymbol{h}_s$ through DFT techniques. To this end we resort to an known frequency-domain method which makes use of side information, adapting it to hybrid TDMA/CDMA systems. We found that a reduction of the mean square channel estimation error by a factor 0.6 can be achieved in UMTS by exploiting a priori knowledge of the transmit filter bandwidth. Letting

$$N_B = \mathrm{int}(PBT) \tag{17}$$

($\mathrm{int}(x)$ indicates the integer part of x) we compute the $2N_{ut}W$-dimensional vector $\boldsymbol{y}$

$$[y]_n = \frac{1}{2P} \sum_{m=-N_B}^{N_B} \frac{X(m)}{A(m)} e^{j\pi mn/P} \qquad 0 \le n \le 2N_{ut}W-1 \tag{18}$$

In (18), $[y]_n$ represents the nth entry of $\boldsymbol{y}$, $X(m)$ is the $2P$-point TDF of the observed vector $\boldsymbol{x}$

$$X(m)=\sum_{k=0}^{2P-1}x(k)e^{-j\pi mk/P}\qquad -P\le m\le P-1 \tag{19}$$

and $A(m)$ is the P-point DFT of the basic code $\boldsymbol{a}$

$$A(m)=\sum_{k=0}^{P-1}a_k e^{-j2\pi mk/P} \tag{20}$$

It can be shown that

$$\boldsymbol{y}=\boldsymbol{h}_s+\tilde{\boldsymbol{w}} \tag{21}$$

where the noise contribution $\tilde{\boldsymbol{w}}$ is a zero-mean Gaussian vector with covariance matrix $\boldsymbol{C}_{\tilde{w}}$. Equation (21) indicates that $\boldsymbol{y}$ is an unbiased estimate of $\boldsymbol{h}_s$ and is normally exploited in the uplink of the UMTS-TDD component as an estimate of the channel impulse responses associated to the active users.

To proceed, we divide $\boldsymbol{y}$ into N_{ut} subvectors $\{\boldsymbol{y}_i, 1\le i\le N_{ut}\}$, each of length $2W$

$$\boldsymbol{y}^T=[\boldsymbol{y}_1^T\ \boldsymbol{y}_2^T\ldots\boldsymbol{y}_{N_{ut}}^T] \tag{22}$$

The kth entry of $\boldsymbol{y}_i$ is given by

$$[\boldsymbol{y}_i]_k=[\boldsymbol{y}]_{k+2(i-1)W} \tag{23}$$

Bearing in mind (21) and (13) we get

$$\boldsymbol{y}_i=\gamma_i\boldsymbol{h}+\tilde{\boldsymbol{w}}_i\qquad i=1,2,\ldots,N_{ut} \tag{24}$$

where $\tilde{\boldsymbol{w}}_i$ is the ith subvector of $\tilde{\boldsymbol{w}}$. It is worth noting that $\boldsymbol{y}_i$ represents an estimate of the channel $\gamma_i\boldsymbol{h}$ associated to the ith user.

The key idea of the invention is of jointly estimating vectors $\boldsymbol{h}$ and γ starting from $\boldsymbol{y}$. With this approach the channel estimation accuracy is superior to that achieved with other existing methods because we exploit the aggregate of all the active users' signals rather than a single signal, and further, it is possible to accurately identify whether a given user is active or not. To this end we resort to the least square criterion

$$(\hat{\boldsymbol{h}},\hat{\gamma})=\arg\min_{(\tilde{\boldsymbol{h}},\tilde{\gamma})}\left\{\sum_{i=1}^{N_{ut}}\left\|\boldsymbol{y}_i-\tilde{\gamma}_i\tilde{\boldsymbol{h}}\right\|^2\right\} \tag{25}$$

where $\|\cdot\|$ indicates the Euclidean norm of a vector while $\tilde{\boldsymbol{h}}$ and $\tilde{\gamma}$ are trial values of $\boldsymbol{h}$ and γ. Since the minimization (25) cannot be solved in closed form, it will be split into two simpler problems: *i*) estimation of γ assuming $\boldsymbol{h}$ known; *ii*) estimation of $\boldsymbol{h}$ assuming γ known. As we

explain later, a solution to (25) can be achieved through an iterative procedure.

*Estimation of γ assuming **h** known*

In this case problem (25) reduces to

$$\hat{\gamma}_i = \arg\min_{\tilde{\gamma}_i}\left\{\left\|y_i - \tilde{\gamma}_i h\right\|^2\right\} \qquad i = 1,2,\ldots,N_{ut} \tag{26}$$

and its solution is found to be

$$\hat{\gamma}_i = \frac{\Re\mathrm{e}\left\{y_i^H \boldsymbol{h}\right\}}{\|\boldsymbol{h}\|^2} \qquad i = 2,3,\ldots,N_{ut} \tag{27}$$

where $\Re\mathrm{e}(x)$ denotes the real part of a number x.

*Estimation of **h** assuming γ known*

In this case problem (25) reduces to

$$\hat{\boldsymbol{h}} = \arg\min_{\tilde{h}}\left\{\sum_{i=1}^{N_{ut}}\left\|y_i - \gamma_i \tilde{h}\right\|^2\right\} \tag{28}$$

and its solution is

$$\hat{\boldsymbol{h}} = \frac{\sum_{i=1}^{N_{ut}}\gamma_i y_i}{\sum_{i=1}^{N_{ut}}\gamma_i^2} \qquad (\gamma_1 = 1) \tag{29}$$

*Joint estimation of **h** and γ*

Equations (27) and (29) can be used to jointly estimate vectors $\boldsymbol{h}$ and γ in an iterative fashion. Denoting by $\hat{\boldsymbol{h}}^{(k)}$ and $\hat{\gamma}^{(k)}$ the estimates of $\boldsymbol{h}$ and γ at the kth iteration, the next estimates are computed as

$$\hat{\gamma}_i^{(k)} = \frac{\Re\mathrm{e}\left\{y_i^H \hat{\boldsymbol{h}}^{(k-1)}\right\}}{\left\|\hat{\boldsymbol{h}}^{(k-1)}\right\|^2} \qquad i = 2,3,\ldots,N_{ut} \qquad k = 1,2,\ldots \tag{30}$$

$$\hat{\boldsymbol{h}}^{(k+1)} = \frac{\sum_{i=1}^{N_{ut}}\gamma_i^{(k)} y_i}{\sum_{i=1}^{N_{ut}}[\gamma_i^{(k)}]^2} \qquad (\gamma_1^{(k)} = 1) \qquad k = 1,2,\ldots \tag{31}$$

Simulations indicate that the iterative algorithm (30)-(31) converges toward the solution of (25) in 2-3 iterations. However, it needs an initial channel estimate $\hat{\boldsymbol{h}}^{(0)}$. Once $\hat{\boldsymbol{h}}^{(0)}$ is available,

initial amplitude estimates $\hat{\gamma}^{(0)}$ can be computed through (30). Given $\hat{\gamma}^{(0)}$ we compute $\hat{h}^{(1)}$ by means of (31) ... and so on. To see how to get $\hat{h}^{(0)}$, we momentarily return to (24). Bearing in mind that $\gamma_1 = 1$, it is easily seen that y_1 represents a noisy version of h. Thus, we can simply assume $\hat{h}^{(0)} = y_1$.

It is worth noting that the estimate of γ can be used to decide whether a given user is active or not. To be specific, the ith user is declared active if $\hat{\gamma}_i$ exceeds a given threshold λ, otherwise it is declared turned off.

In Tables I and II the MSE as obtained by simulation with the proposed method is indicated as $MSE_{M\&M}$ and is compared with the theoretical limit MSE_{bound} given in (8). We have also reported the MSE as obtained with the conventional channel estimation method used in the uplink, indicated with the acronym MSE_{std}. The conventional method is expressed by

$$\hat{h}_{std} = z_1 \tag{32}$$

where z_1 is a vector containing the first $2W$ entries of

$$z = (P^H P)^{-1} P^H x \tag{33}$$

Substituting (12) in (33) it is found

$$z = h_s + \mu \tag{34}$$

with $\mu = (P^H P)^{-1} P^H w$. Eq. (34) indicates that z is an unbiased estimate of h_s. A third estimation scheme is obtained by reasoning in the following way. We divide z in N_{ut} subvectors $\{z_i, 1 \leq i \leq N_{ut}\}$, each of dimension $2W$

$$z^T = [z_1^T\ z_2^T \ldots z_{N_{ut}}^T] \tag{35}$$

with the kth entry of z_i given by

$$[z_i]_k = [z]_{k+2(i-1)W} \tag{36}$$

Bearing in mind (34) and (13) it is seen that

$$z_i = \gamma_i h + \mu_i \qquad i = 1,2,\ldots,N_{ut} \tag{37}$$

where μ_i is the ith subvector of μ. Thus, a channel estimate can be obtained starting from the subvectors z_i through the following *ad hoc* algorithm

$$\hat{h}_{ah} = \frac{\sum_{i=1}^{N_{ut}} \eta_i z_i}{\sum_{i=1}^{N_{ut}} \eta_i^2} \tag{38}$$

where the coefficients $\{\eta_i\}$ are expressed by

$$\eta_i = \frac{\|z_i\|}{\|z_1\|} \qquad i = 2,3,\ldots,N_{ut} \qquad (\eta_1 = 1) \tag{39}$$

The results in Tables I and II are normalized to MSE_{std} and have been obtained with the channel model 3 as standardized by 3-GPP [3-Generation Partnership Project] assuming that all users have equal power. It is seen that the accuracy of the proposed method is close to the bound and is much better than that achieved by the ad hoc scheme, at least at signal-to-noise ratio of practical interest (6-8 dB).

Active_Users	MSE_{bound}	$MSE_{M\&M}$	MSE_{std}	MSE_{ah}
2	-5.4 dB	-4.3 dB	0. dB	+2.5 dB
4	-8.4 dB	-6.6 dB	0. dB	-1.8 dB
8	-11.4 dB	-9.0 dB	0. dB	-8.5 dB

Tab.1 Performance comparison at SNR=6.dB.

Active_Users	MSE_{bound}	$MSE_{M\&M}$	MSE_{std}	MSE_{ah}
2	-5.4 dB	-4.7 dB	0. dB	+2.9 dB
4	-8.4 dB	-6.8 dB	0. dB	-1.5 dB
8	-11.4 dB	-9.1 dB	0. dB	-9.0 dB

Tab.2 Performance comparison at SNR=8.dB.

The proposed algorithm (30)-(31) can be used to decide whether a given user is active or not. Identification of the active users is an open problem in the standardization process, as clearly indicated in several 3-GPP documents where it is proposed the use of a separated channel to transmit information about the active users in the slot in order to minimize the probability of false codes' detection. A simple data detector for the downlink is based on the fact that the spreading codes are perfectly orthogonal and all user signals arrive at the mobile station through the same channel. In a frequency-selective environment the spreading codes lose their orthogonality. To mitigate this problem we may resort to a standard linear equalizer (to restore codes' orthogonality), followed by a single-user receiver. This detector is much simpler than

those described previously and its performance is only 1.5 dB worse if the equalizer coefficients are computed according to the MMSE criterion and the channel selectivity is not too severe. Obviously, the choice of the equalizer's taps requires knowledge of the channel impulse response. It is found that if the proposed channel estimator is used, the performance of the reduced complexity data detector is superior to that achieved with other more complex schemes operating with traditional channel estimation methods.

CLAIMS

1- Method for estimating channels in a receiver for the downlink of the TDD component of the UMTS standard by using training sequences, contained in a midamble of the TDD component, transmitted to the receiver for estimating channel response (***h***) and the powers of the active users in the link (γ) characterised in that comprises iterative steps ((30), (31)) that jointly estimate the channel impulse response (***h***) and the powers of the active users in the link (γ), in order to implement optimal and sub-optimal multiuser detection procedures.

2- Method for estimating channels in a receiver according to claim 1 characterised in that said iterative steps ((30), (31)) that jointly estimate the channel impulse response (***h***) and the powers of the active users in the link (γ) are based on evaluation of a estimation vector (*y*).

3- Method for estimating channels in a receiver according to claim 2 characterised in that said estimation vector (*y*) represents a unbiased estimate of a vector ($\boldsymbol{h}_s$) containing scaled versions of the channel response (***h***).

4- Method for estimating channels in a receiver according to claim 1, characterized by the fact that, the vector representing powers of the active users in the link (γ)and derived from the iterative steps ((30), (31)), is used to detect the active users in the link and their spreading codes used by the TDD, making use of the association between codes and midambles established by the UMTS standard.

5- Method for estimating channels in a receiver according to claim 4, characterized in that the detected spreading codes of the active users are used to implement multiuser detection techniques.

6- Method for estimating channels in a receiver according to claim 3, characterized by the fact that the estimation of vector ($\boldsymbol{h}_s$) containing scaled versions of the channel response (***h***), is performed through calculation ((18)) of components $[y]_n$ of the estimation vector y and from a relation (21) $y = \boldsymbol{h}_s + \tilde{w}$ where $\tilde{w}$ is a zero-mean Gaussian vector of noise contribution, in order to exploit the knowledge of the transmission filter bandwidth.

7- Method for estimating channels in a receiver according to claim 3, characterized by the fact that the vector ($\boldsymbol{h}_s$) containing scaled versions of the channel response (***h***) provides both an initial estimate of the channel ($\hat{h}^{(0)}$)needed in the iterative steps ((30), (31)) and the estimate of the channel responses in the uplink.

8- Receiver for mobile stations in hybrid TDMA/CDMA systems comprising means for channel estimation by using training sequences, contained in a midamble of the TDD component, transmitted to the receiver for estimating channel response (***h***) and the powers of the active users in the link (γ) characterised in that said means for channel estimation

jointly estimate the channel input response (***h***)and the powers of the active users in the link (γ) according to the method of claims 1 to 7.

9- Receiver for mobile stations according to claim 8 characterized in that comprises a standard linear equalized followed by a single user receiver.

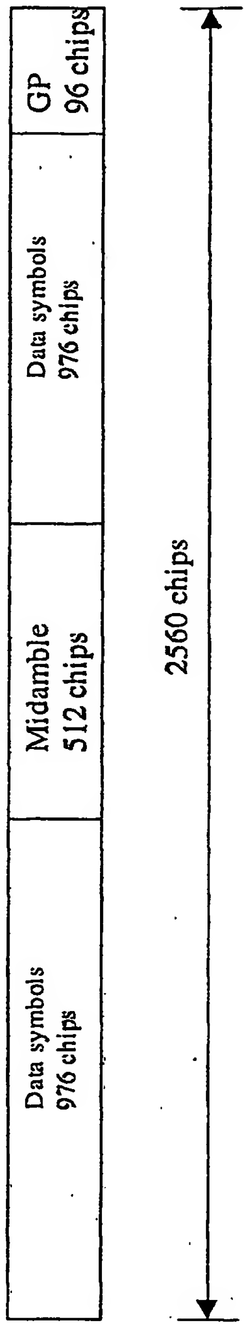
Data symbols
976 chips
Midamble
512 chips
Data symbols
976 chips
GP
96 chips
2560 chips

FIG. 1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 01/01303

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L25/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WEISS, FRIEDLANDER: "Channel estimation for synchronous DS-CDMA downlink" IEEE SIGNAL PROCESSING WORKSHOP ON STATISTICAL SIGNAL AND ARRAY PROCESSING, 14 - 16 September 1998, pages 284-287, XP002178851 New York, US section 4 section 6	1-9

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
28 September 2001	12/10/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Scriven, P

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International Application No
PCT/IB 01/01303

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